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Yu Liu

Jack Chan

Qin Zhang

Xiantao Sun

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Call Audio Quality Determination and Root Cause Analysis Using Machine Learning

ABSTRACT

Accurate assessment and categorization of real-world audio quality in a call, e.g., a call over VoLTE/VoNR, is essential to provide a satisfactory call experience. However, current techniques to determine call quality do not accurately categorize the audio quality. Also, there are no techniques to determine the root cause of poor audio quality or to identify potential solutions. This disclosure describes the use of machine learning clustering techniques to cluster audio metrics and using the obtained clusters to generate a root cause table. Further, a classifier is trained to determine whether an ongoing call has unsatisfactory audio quality. The quality can be categorized and labeled, e.g., good, mildly choppy, severely choppy, and no audio. If the audio quality is unsatisfactory, the likely root cause is identified using the root cause table to identify and apply solutions while the call is in progress. The described techniques are a closed loop technique to identify solutions to audio quality problems in an audio call.

KEYWORDS

- Root cause analysis
- Root cause table
- Choppy audio
- Audio quality
- Voice quality
- Clustering algorithm
- Audio quality metrics
- Voice over LTE (VoLTE)
- Voice over New Radio (VoNR)

BACKGROUND

Mobile users that communicate over Voice over LTE (VoLTE) or Voice over New Radio (VoNR) may experience instances of pauses, mute (no audio from other side), and/or choppy audio during call sessions even as the real-time voice call continues with a connected network.

This is a suboptimal experience and occurs when the participating devices are experiencing poor quality conditions. Efficiently detecting real-world call performance and fixing the poor quality issues is necessary to improve the user experience. However, there are no current techniques to either evaluate the real-time audio quality, to identify root cause of poor quality, or to identify recommended solutions.

A wireless modem can provide network traffic statistics such as real-time transport protocol (RTP) packet loss, delay, audio codec rates, network performance, etc. Poor call quality can be caused by many factors such as poor network connections, modem software issues, hardware issues, etc. Some techniques (e.g., [1]) to determine reasons for poor audio quality focus on calculating R factors or mean opinion score (MOS) as performance metrics of call quality. However, such techniques cannot accurately categorize the real world call quality and conditions such as mild choppy, severe choppy, or no audio. There is no work to determine the root cause for poor quality audio. There are no closed-loop systems that can provide recommendations of actions to improve audio quality.

DESCRIPTION

This disclosure describes the use of machine learning clustering techniques to cluster audio metrics and using the obtained clusters to generate a root cause table. Further, a classifier is trained to determine whether an ongoing call has unsatisfactory audio quality. The quality can be categorized and labeled, e.g., good, mildly choppy, severely choppy, and no audio. If the audio quality is unsatisfactory, the likely root cause is identified using the root cause table to identify and apply solutions while the call is in progress. The described techniques are a closed loop technique to identify solutions to audio quality problems in an audio call.

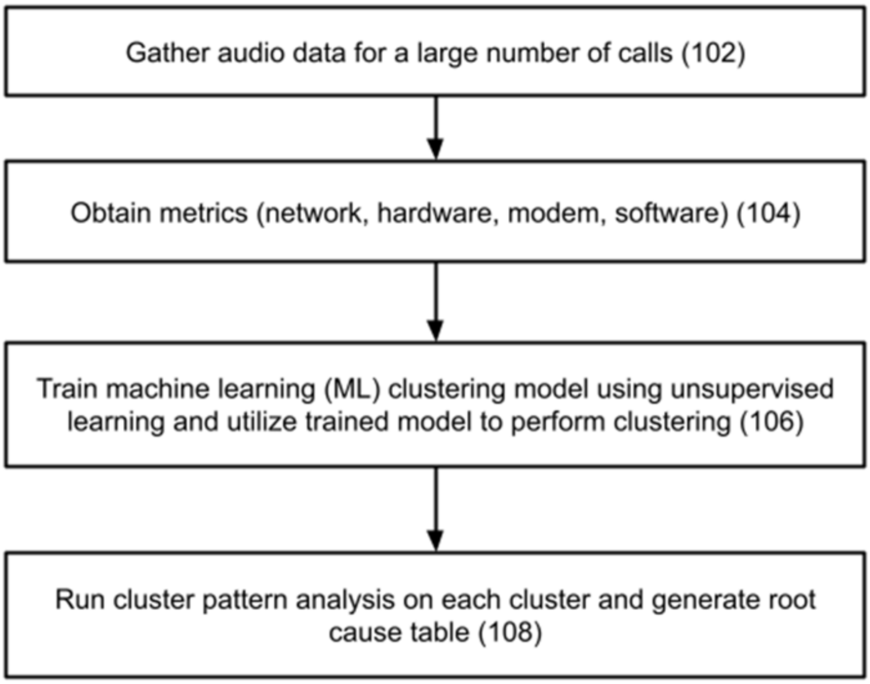

Fig. 1: Obtaining a root cause table using machine learning clustering model

Fig. 1 illustrates an example method to obtain a root cause table that identifies potential root causes for poor audio quality. With user permission, data for a large number of calls is gathered (102). Relevant metrics are obtained (104) from the gathered data. For example, such metrics can include metrics related to the network, device hardware and software, and the modem. A machine learning clustering model is trained (106) on the metrics, e.g., using unsupervised algorithms such as K-means clustering. The trained model is evaluated, and parameters of the model are tuned until a threshold level of model performance is reached. The trained model is used to obtain clusters based on the metrics.

Cluster pattern analysis is performed (108) to generate the root cause table. For example, for a cluster that has a high packet loss rate and/or a high number of maximum consecutive packets lost, network congestion related metrics are analyzed. In another example, for a cluster with relatively low packet loss but high number of maximum consecutive packets lost, radio frequency (RF) related metrics may be analyzed. Any number of characteristics may be obtained for each cluster. A root cause table is generated based on the cluster pattern analysis. For example, the root cause table may include two columns - a cluster ID column and a list of potential root causes (with priority order, if determined).

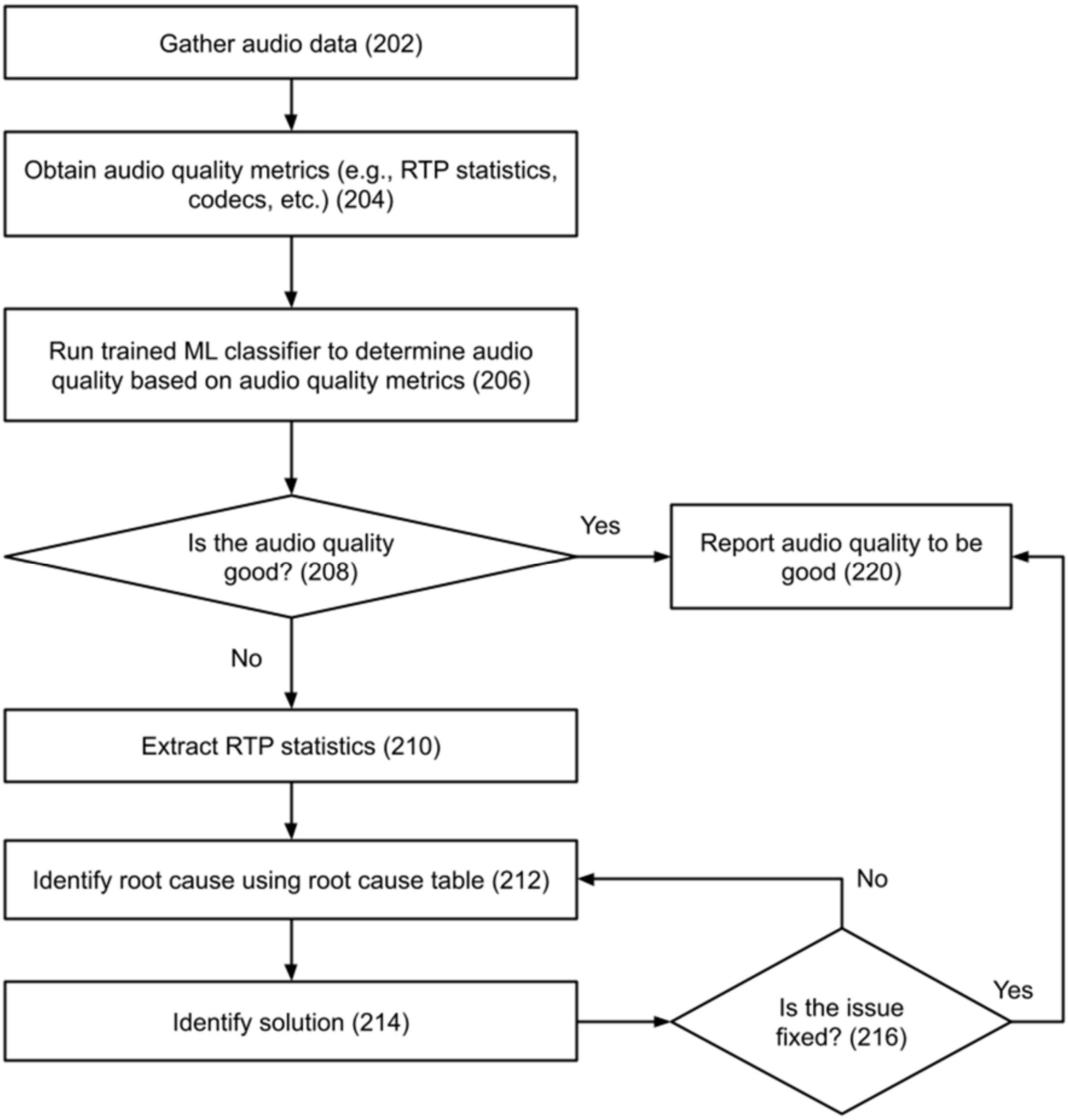

Fig. 2: Determining root cause and identifying solutions for poor audio quality

Fig. 2 illustrates an example method to automatically determine whether the call quality of an audio call is good and if it is determined to not be satisfactory, perform root cause analysis to identify solutions. With appropriate user permissions, audio data from a call are gathered (202). Audio quality metrics such as real time protocol (RTP) statistics and codecs are obtained (204) based on the audio data.

A pre-trained machine learning (ML) classifier (or other suitable classifier) is utilized to determine the audio quality (206) for the call based on the audio quality metrics. For example, the metrics can include real time protocol (RTP) packet loss data, maximum number of consecutive packets that were lost, audio codec information, etc. The ML classifier provides an indication of the audio quality. If the audio quality is good (208), it is reported as such (220). If the output of the ML classifier indicates poor audio quality (e.g., below a threshold), real-time transport protocol (RTP) statistics are extracted (210).

Root cause analysis (212) is performed based on the extracted statistics and on the root cause table generated as described above with reference to Fig. 1. A likely root cause is identified (212) from the root cause table. For example, such a root cause may include network congestion, radio frequency (RF) interference. Based on the identified root cause, a solution is identified (214). For example, if the root cause is network congestion, the recommended solution may include “increase/improve network bandwidth” and/or “prioritize network traffic.” If the identified solution resolves the issue (216), the audio quality is reported to be good (220). If the identified solution does not resolve the issue, the next likely root cause is identified, and a corresponding solution is identified.

CONCLUSION

This disclosure describes the use of machine learning clustering techniques to cluster audio metrics and using the obtained clusters to generate a root cause table. Further, a classifier is trained to determine whether an ongoing call has unsatisfactory audio quality. The quality can be categorized and labeled, e.g., good, mildly choppy, severely choppy, and no audio. If the audio quality is unsatisfactory, the likely root cause is identified using the root cause table to identify and apply solutions while the call is in progress. The described techniques are a closed loop technique to identify solutions to audio quality problems in an audio call.

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